

## **CLAIM(S)**

What is claimed is:

(1) An aerosol inhalation apparatus, comprising:

- collapsible/expandable first housing or a fixed first housing or a partially fixed and a partially collapsible/expandable first housing with a configuration of a cylinder, a bell, a pear, a cone, or any three dimensional polygon;
- a first housing that is fully collapsible into a substantially compact minimum volume, fully expandable to a maximum volume and partially expandable to different volumes;
- a collapsible/expandable second housing or a fixed second housing or a partially fixed and partially collapsible/expandable second housing;
- the first housing that is connected to the second housing through one or more peripheral and/or central hollow connecting tubes;
- the first housing with an inhalation / exhalation outlet tube at an inhalation /exhalation end of the first housing;
- the inhalation / exhalation outlet tube with an inhalation /exhalation outlet port at the end of the inhalation/exhalation outlet tube;
- a mouthpiece or a facemask connected to the inhalation / exhalation port of the inhalation / exhalation outlet tube;
- the first housing with an inlet tube at a diametrically opposite end of the inhalation/exhalation outlet tube;
- the inlet tube with an inlet port at an end of the inlet tube;
- a boot adapter panel that may be connected to the inlet port of the inlet tube of the first housing;
- the boot adapter panel with an opening for receiving a boot of an MDI inhaler;
- a one way inhalation flap valve assembly that comprises of an inhalation flap valve and a valve seat for the inhalation flap valve that is disposed in the outlet port of the outlet tubing of the first housing;
- the one way inhalation valve assembly whereby inhalation by a patient through the inhalation / exhalation outlet port will cause the inhalation flap valve to move away from the inhalation flap valve seat to allow one way flow of gas(es) from the first housing to a mouth piece or a face mask and exhalation by a patient through the

inhalation/exhalation outlet port of the first housing presses the inhalation flap against the inhalation flap valve seat to prevent the flow of exhaled gas into the first housing;

- a one way exhalation flap valve assembly with an exhalation flap valve with and exhalation flap valve seat for the exhalation flap valve that is disposed in a wall of the outlet port of the first housing;
- the one way exhalation flap valve assembly whereby exhalation by a patient through the inhalation/exhalation outlet port will cause the exhalation flap valve to move away from the exhalation flap valve seat to allow one way flow of gas exhaled from the outlet tube to outside atmosphere;
- the one way exhalation flap valve assembly whereby exhalation by a patient through the inhalation / exhalation outlet port will cause exhalation flap valve to move away from the exhalation flap valve seat to allow one way flow of gas from the mouthpiece or the face mask to outside atmosphere and inhalation by a patient through the inhalation / exhalation outlet port will press the exhalation flap valve against the exhalation flap valve seat to prevent the flow of gas from atmosphere to the mouthpiece or facemask or the first housing and hence a patient;
- said one way exhalation flap valve assembly further comprising an exhalation filter in said valve assembly to trap all exhaled aerosol medication but allowing all exhaled gas(es) to escape to atmosphere.

(2) The aerosol inhalation apparatus of claim one, comprising:

- a collapsible / expandable first and/or second housing composed of a single piece of material that may be plastic, paper, or metal or a housing that may be composed of a combination of different such materials;
- said housing that may be composed of a stiff corrugated plastic material with multiple ridges and grooves or pleats like an accordion that may be collapsible/expandable
- said housing that does not require any support with a metal or plastic wire for patency;
- said housing that is expandable to a maximum volume by fully stretching all the pleats of the housing and fully collapsible by pulling all the pleats of the housing together and partially expandable/collapsible to any volume between maximum and minimum volumes by pulling the pleats together or stretching them apart;

- said housing with an inlet and an outlet end;
- said housing that may be supported by a metal or plastic wire with 2 free ends;
- the wire, one free end of which terminates at or near the inlet end of the housing and other free end of which terminates at the outlet end of housing;
- said wire that has a configuration of a coil and is arranged in spirals or multiple concentric rings;
- said coil is expandable when the rings are pulled apart;
- said coil is collapsible when the rings are pulled together;
- said housing is expandable when the coil rings are pulled apart and collapsible when the rings are pulled together;
- said housing is fully expandable to bound a fully expanded maximum volume when each ring is pulled apart from an adjoining ring and fully collapsible to minimum volume when each ring is pulled together to an adjoining ring;
- said housing is expandable to bound a first volume when a first coil ring is fully pulled apart from a second coil ring, and all remaining coil rings are pulled together;
- said first volume is expandable to bound a second volume of said housing when a third coil ring is fully pulled apart from the second spiral ring, and all or remaining coil rings pulled together;
- said second volume of housing is expandable to bound a third volume of housing when a fourth spiral ring is fully pulled apart from the third spiral ring, and all remaining coils pulled together;
- a partially expandable/collapsible volume of said housing between a maximum and a minimum volume that is further expandable to any volume less than the maximum volume by pulling apart a ring from an adjoining ring and collapsible to any volume greater than the minimum volume by pulling together a ring to an adjoining ring;
- said first volume of the housing may be equal to the difference between the second and the first volume, which may be equal to the difference between the third and the second volume, such that each intervening volume obtained by expanding any two adjoining rings may be equal;

- said first volume housing that may be different from the difference between the second and the first volume, such that each intervening volume obtained by expanding any two adjacent rings may be unequal;
- minimum fully collapsible volume wherein the inlet tube of said housing may be fused with the outlet tube of said housing;
- any partially expandable volume of the first housing other than minimum collapsible volume wherein inlet tube of said housing is detached from the outlet tube of said housing;

(3) The aerosol inhalation apparatus of claim one, comprising:

- a fixed volume second housing or collapsible/expandable second housing or a partially fixed and a partially expandable/collapsible second housing;
- a housing composed of a corrugated plastic material with multiple ridges/grooves or pleats like an accordion;
- a collapsible/expandable housing composed of a single piece of material;
- said housing with an inlet end and an outlet end;
- said housing with an inhalation/exhalation outlet tube at the outlet end;
- said housing with one or more inlet tubes at the inlet end;
- said inlet tube which may be connected to one or more sources of gas(es) to receive one or more gas(es) into said housing;
- said inlet tube that may be connected to expandable/collapsible corrugated tubing;
- said corrugated tubing that may be connected to one or more gas sources;
- said housing with two ports disposed in the wall of the housing between the inlet and outlet end – a port for a nebulizer, and a port for a reservoir;
- said outlet end, which is plugged with a cap when using an MDI and said outlet tube of the second housing is fused with the inlet tube of the first housing when using a nebulizer;
- said reservoir which may be an expandable/collapsible corrugated tubing as described in claim 2 and/or a collapsible/expandable bag made of plastic or neoprene;
- said second housing is connected to the first housing with two peripheral collapsible/expandable connecting tubes;

- the two peripheral connecting tubes that are fully or partially expandable during MDI use to allow a central disconnection between the inlet tubing of the first housing and the outlet tubing of the second housing and to create a room to accommodate the MDI boot between the first and the second housing;
- the two peripheral connecting tubes that are fully collapsible to a minimum volume during nebulizer use to allow a central connection between the inlet tube of the first and the outlet tube of the second housing;
- said second housing wherein a nebulizer is connected to the nebulizer port of the housing to generate aerosol medication that is transferred to the first housing via two peripheral connecting tubes and a central connection between two housings via the outlet tube of the second housing and the inlet tube of the first housing;
- said second housing wherein during MDI use, the outlet tube remains plugged with a cap and the MDI is attached to the inlet tube of the first housing via a universal boot adapter assembly and a gas(es) is transferred from the second housing to the first housing via the two peripheral connecting tubes;
- a reservoir which stores aerosol medication generated by the nebulizer during an exhalation phase of the nebuliser to be used in a subsequent inhalation phase of a respiratory cycle;
- a reservoir that may have one or more inlet ports for one or more gas(es) to enter the reservoir for uniform mixing with the aerosol particles before entering the second housing and prior to inhalation by a patient.

(4) An aerosol inhalation apparatus of claim one, comprising:

- two or more peripheral connecting tubes between the first housing and the second housing to allow a passage of aerosol medications and/or one or more gases from the first housing to the second housing;
- said connecting tubes that are cylindrical and are collapsible/expandable;
- said tubes that are collapsible to allow a central fusion of the first housing and the second housing;
- said tubes that could be expanded to make room for accommodating MDI between the first and the second housing;

- said tubes wherein each tube is connected to first and second housing via a single port or opening;
- said tubes wherein each tube after connection with the first housing splits into multiple micrometric openings;
- said multiple micrometric openings that are distributed along the circumference in the inlet of the first housing;
- said openings wherein air entrained into the first housing from the second housing does not interrupt or interfere with a plume generated by an MDI;
- said openings wherein aerosol generated by a nebulizer in the second housing enters the first housing via multiple micrometric openings distributed along entire circumference of the inlet of the first housing.

(5) An aerosol inhalation apparatus of claim one, comprising:

- a universal MDI adapter that may be located at the inlet end of the central inlet tube of the first housing;
- the MDI adapter that may be used for delivering aerosol medication by actuation of MDI into the first housing;
- a nebulizer that may generate aerosol medication in the second housing;
- the first housing and the second housing that are connected at a central location by fusion of the outlet tube of the second housing to the inlet tube of the first housing, such as to form a passage to allow the aerosol medication to move between the two housings;
- the first housing and the second housing that may also be connected at peripheral locations by peripheral connecting tubes that are partially or fully collapsible/expandable such as to form a passage to allow the aerosol medication to move between the two housings.

(6) The aerosol inhalation apparatus of claim 1 :

- useable with a facemask to deliver a desired mixture of gas(es) with a desired density, viscosity, humidity, and fraction of inspired oxygen;

- useable with a facemask to deliver aerosol medication via an MDI and/or a nebulizer with a desired mixture of gas(es) with a desired density, viscosity, humidity, and fraction of inspired oxygen;
- useable in a ventilatory circuit by connecting the outlet tube at the outlet end of the first housing at one end of the ventilatory circuit and the inlet tube at the inlet end of the second housing at other end of the ventilatory circuit;

(7) Aerosol inhalation apparatus of claims 2,3,4,5 and 6 comprising:

- a collapsible/expandable or fixed volume first housing;
- a fixed volume, or collapsible/expandable second housing;
- a central connection between the first and the second housing during nebulizer use and during delivery of a desired mixture of gases with or without aerosol medication delivery;
- one or more peripheral connections between the first and the second housing that are collapsible during nebulizer use and expandable during MDI use;
- the peripheral connections that permit delivery of a desired mixture of gas (es) with or without aerosol medication from the second housing to the first housing and hence to a patient;
- the peripheral connections between the first and the second housings that allow a desired mixture gas (es) to be delivered from the second housing to the first housing that is distributed in a pattern that does not interfere with a plume generated by the MDI or the nebulizer;
- first housing, second housing and/or reservoir that are all collapsible/expandable and could be used for pediatric and/or adult patients by expanding and/or collapsing the housings and/or reservoir to a precise desired volume;
- second housing that has a collapsible/expandable reservoir which may be a bag or a corrugated plastic tubing to store aerosol generated during exhalation, and to allow uniform mixing of one or more gases with aerosol medication to be delivered during inhalation to a patient;
- a second housing with one or more inlets for one or more gases to yield and deliver a gas mixture with a desired humidity, density, viscosity, and fraction of inspired oxygen to a patient;

- a closed circuit that serve as 100% non rebreather system with an inhalation valve assembly to prevent any air to be entrained from atmosphere into a circuit during inhalation and an exhalation valve assembly to allow exhaled air to exit a circuit into atmosphere and not allowing rebreathing of the exhaled air;
- a filter that is incorporated into the exhalation valve assembly to trap exhaled aerosol medication, allowing the exhaled gases to escape from the closed circuit to atmosphere and not permit entrainment of gases from atmosphere into the closed circuit;
- an enhanced aerosol delivery via MDI or nebulizer separately or simultaneously via MDI and nebulizer with delivery of a gas mixture of a desired density, viscosity, humidity, and fraction of inspired oxygen during aerosol delivery without disconnecting a patient from a desired gas source during aerosol delivery;
- a reservoir which may be moveable or could be repositioned in the apparatus such that it may be in front of the nebulizer, behind the nebulizer, connected to the nebuliser with a Y or Tee connector may be located in the second housing or be placed in the first housing before the inhalation valve assembly
- The collapsible/expandable first housing that may serve as a reservoir in a closed circuit to store aerosol medication during exhalation if expanded to a certain minimum volume to meet a patient's ventilatory requirement such that no additional reservoir bag or collapsible/expandable corrugated tube may be required as a reservoir in the second housing;

(8) An aerosol inhalation apparatus of claims 1 and 7 comprising:

- a single fixed collapsible/expandable or partially fixed and partially collapsible/expandable first housing;
- the housing has an outlet port for connection to a facemask or a mouthpiece;
- the outlet has two flap valve assemblies—an inhalation and an exhalation valve assembly;
- the housing that has an inlet port for connection with a boot adapter panel;
- the housing that has a port for a nebulizer and a reservoir that is disposed in a wall of the housing between the inlet and outlet ports;
- an inhalation valve assembly in the outlet tube of the first housing which may be a ball valve assembly and not a flap valve assembly such that inhalation by a patient triggers

a ball to rise to a higher level and drop to it's original position during exhalation to allow one way flow of aerosol medication and/or gases to a patient and not allow any re-breathing of carbon dioxide exhaled by a patient.